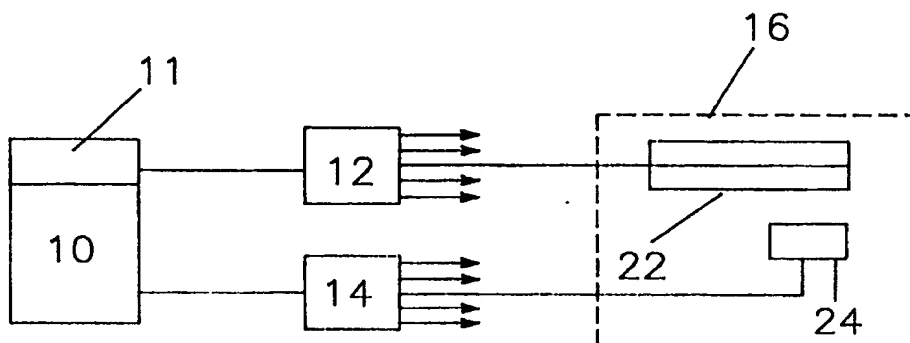




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(54) Title: SENSORY COMMUNICATION APPARATUS**(57) Abstract**

Tactile communication apparatus comprising a central processing unit (10) having a data store (11), an output processor (12), means for controlling the output of data from the data store (11) to the output processor (12), and output means (16) connected to receive data from the processor, the output means having tactile sensor units responsive to the output data whereby the output of the computer can be determined by touch.

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SENSORY COMMUNICATION APPARATUS

5

This invention is concerned with a sensory communication apparatus, and in particular to such apparatus for the dynamic display to a blind person of textual and graphical information.

10 Maps are used for three main purposes, namely for education, such as the study of geography, for planning a journey, and for navigation during a journey.

The tasks of exploration are similar in the three cases and
15 are essentially to discover the locations, names and characteristics of, and relationships between, real-world objects or features, both natural and man-made. The goal of exploration may be to establish the layout of a place, or more specifically to find a suitable route from one place to another.

20

There have been a number of developments in making maps accessible for blind people. Firstly there are the maps which are purely tactile and in which writing is in Braille, as raised dots, and texture is used as a substitute for colour. Such maps
25 are "crude" in that there can be little detail, and resolution is small. Thus only a limited amount of information can be presented for a given size of map - several orders of magnitude less than a conventional map used by sighted people. There are problems of producing tactile maps, though there have been
30 technical developments to improve the situation. The cost of reproduction (i.e. the per copy cost) is still high.

Similar problems arise in the presentation of other multi-dimensional information including graphs, charts, block diagrams,
35 tables and matrices. Even with a simple table the single line display of a conventional dynamic Braille apparatus can lead to confusion because the line crosses the columns.

There have been various attempts to get away from a
5 "hard-copy" approach and substitute a dynamic tactile display,
using a physical surface which can be altered under control of
a computer. These displays are expensive because the surface is
composed of a large array of movable elements, but the cost of
map reproduction (i.e. producing copies of a map to distribute)
10 is negligible since the maps are in electronic form.

It is an object of the present invention to obviate or
mitigate these difficulties.

15 The present invention is sensory communication apparatus
comprising a central processing unit having a data store, an
output processor, means for controlling the output of data from
the data store to the output processor, and output means
connected to receive data from the processor, the output means
20 being responsive to the output data whereby the output of the
computer can be determined by one or more of the user's senses
of touch, sound or sight.

The means for controlling the output of the data store may
25 comprise a pointing device.

Preferably the output means includes tactile elements in the
form of pins, each having associated with it an electro-
mechanical transducer.

30

Preferably the pins are also associated with respective
switches which are connected through an input processor to the
central processing unit.

35

The pins may be arranged in pairs each for simultaneous
contact by a respective finger and each pin of each pair can be
vibrated at different frequencies or with different pulse
lengths.

The output means may be operable in either a character mode
5 or a surface mode.

Preferably the patterns in which the pins are actuated are related to text characters.

10 The apparatus may include a speech synthesiser responsive to data output from the central processing unit.

Preferably a keyboard or keypad is connected through an input processor to the central processing unit.

15 The keyboard or keypad may be operable in a character mode or a control mode.

Graphical information may be held in the data store of the
20 central processing unit as a virtual surface, over which moves a notional cursor. The data output reflects the graphical information under the cursor, and the relative position of graphical objects on the surface. A selected graphical object can be described to the user in text, which is output using the
25 same tactile device, or using audio (speech) or visual display.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

- 30
- Fig.1 is a block circuit diagram of an embodiment of the present invention;
 - Fig.2 is a more detailed circuit diagram of part of Fig.1;
 - 35 Fig.3 is a more detailed circuit diagram of part of Fig.2;
 - Fig.4 is a side elevation of an input/output sensor;

5 Figs.5 is a plan view of a tactile input/output unit; and
Fig.6 is a side view of the tactile input/output unit of
Fig.5.

Referring now to Fig.1, tactile communication apparatus
according to an embodiment of the present invention comprises a
10 central processing unit 10 having a data store 11 and being
connected through an output processor 12 and an input processor
14 to a number of tactile sensors 16 mounted on an input/output
unit 18 (Fig.5). The input and output processors need not, of
course, be separate units but may be provided in a single
15 integrated circuit.

The sensors 16 of this embodiment are shown in Fig.4 and it
should be noted that each sensor 16 is an input/ output device
that both generates a mechanical movement in response to output
20 signals received from the output processor 12 and generates
signals in response to a mechanical input, the signals being
passed to the central processing unit 10 through the input
processor 14.

25 Referring now to Fig.4, each sensor 16 comprises a pair of
pins 20, a pair of electro-mechanical transducers, in this
embodiment piezo strips 22, and a pair of membrane switches 24
mounted on a printed circuit board 26 supported from the top
plate 28 of the unit 18. The strips 22 are clamped at one end and
30 mount the pins 20 at their other end, the pins 20 projecting
upwardly through the top plate 28. The switches 24 are each
mounted beneath a respective pin 20 to be closed by the piezo
strip when the pin is depressed.

35 In Fig.2 the output processor 12 is shown to comprise,
connected in cascade, a level translator 34, a pulse width
modulator generator 36, a high voltage digital amplifier 38 and

5 a number of low pass filters 40 each connected to a respective piezo strip 22 in a sensor 16. In this embodiment twelve low pass filters 40 are provided. The output processor is powered from a low voltage source, preferably a battery, connected to a step-up voltage convertor 42 the high voltage output of which powers the processor more efficiently than would a low voltage.

10

The details of the pulse width modulation generator 36 are shown in Fig.3. The generator 36 consists of four sources that may be mapped onto any combination of sixteen outputs. The sources are controlled by a control unit 50 which interprets the
15 commands and data incoming from the computer 10 via the level translator 34 and controls the various aspects of pulse generation.

Each of the four sources generates an arbitrary wave of a
20 number of different amplitudes and frequencies and comprises a phase accumulator 52a, 52b, 52c, or 52d, which is set to step through a respective look-up table 54a, 54b 54c, or 54d, at a configurable rate whereby the frequency can be varied by altering the step and the waveform can be altered by using a number of
25 different look-ups. The output from the look-up table is then scaled by a respective scaler 56a, 56b, 56c or 56d, according to the desired amplitude.

The four current samples to be output are passed to their
30 respective pulse width generators 58a-58d which create pulses which have widths proportional to the desired value.

Any of the generators can be fed to any of the outputs. This is achieved by preloading a mask register 60a, 60b, 60c or 60d
35 with the output pattern for the respective pulse width generator. When the generator is generating a pulse, this output word is fed through. When the generator is not generating a pulse, the output

mask is gated off and therefore does not play a part in the
5 output.

The sixteen outputs from each of the four generators are
mixed together using an exclusive- OR gate 66. This results in
a true mixing of the four sources when the resultant waveform has
10 passed through its filtering process.

In embodiments allowing access to maps or other graphical
information, the array of transducers are mounted on, or are
otherwise associated with, a pointing device, such as a computer
15 mouse or a touch sensitive tablet. As the mouse moves, or a
depression moves across the tablet, the window is correspondingly
moved over the virtual surface representing the map or graphical
image.

20 To allow a map to be scaleable over a wide range of scales,
the information can be stored at various levels of detail, with
the greater detail suppressed for smaller-scale presentation.
Thus for example, on a large scale the map may show the exact
shapes of buildings, on a smaller scale building may be
25 represented as simple rectangles, and on a smaller scale still
the buildings may be merged into a single object representing a
built-up area. In the current invention, the user can zoom in
and out at will, which compensates for the small size of window.

30 In Fig.5 is shown the plan view of a tactile input/output
unit 18 which is similar to a computer mouse in that it has a
mouse ball 88 (Fig.6) on its underside and can therefore serve
as a pointing device. In addition the unit 18 is provided with
four tactile sensors (70, 72, 74, and 76) each having a pair of
35 pins 20 projecting through its upper surface and two sensors
having two pairs of pins 84, 86, as seen in Fig.6, projecting
through each of its sides 78 and 80. The sixteen pins 20 have

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associated respective transducers in the form of piezo strips 22
5 each connected to a respective one of the low pass filters 40 of
Fig.2.

The unit is, in use, held in the hand with the four fingers
engaging the four pairs of pins at its upper surface and the
10 thumb engaging one of the two pairs of pins at the sides
depending upon which hand is holding the unit.

In embodiments of the invention there are two modes of
operation, namely character and surface.
15

In character mode, output is by characters, each a pattern
on the pins formed as follows. Each pair of pins has three states
determined by the frequency of vibration of the piezo strips; in
the first state one of the strips vibrates at a low frequency (20
20 Hz), in the second state both piezo strips vibrate at the low
frequency and in the third state both piezos vibrate at a higher
frequency (200 Hz). With one of the four finger pairs on there
are three times four states, i.e. twelve states. With one of the
two thumb pairs on there are six states. The alphabet is coded
25 by patterns comprising either a single finger state, or a single
finger state combined, simultaneously or sequentially, with a
single thumb state.

In surface mode, the output corresponds to the virtual
30 surface under the fingers. The piezo strips vibrate according to
an algorithm based on frequency and distance from vectors forming
virtual objects on the surface.

In a modified embodiment the states of the pins are
35 distinguished by the length of the vibration pulses as well as
or instead of by the frequency of vibration.

Furthermore, embodiments of the invention have two input
5 modes, namely character and control.

In character mode the input is via keys, i.e. the pins 20,
acting on the input switches 24 mounted under the piezo strips.
Patterns of input can be produced to correspond to patterns of
10 output. Three input stimuli are possible per finger,
corresponding to the three output states per finger, one
pin/piezo depressed, the other depressed, and both depressed.

In control mode, input is again via the keys and
15 switches 24. A single keystroke is used for simple commands such
as Next, Previous, Up, Down, Enter and Leave. These commands are
used for navigating in information space, typically for exploring
a document hierarchy, and for editing. The same commands are used
at all levels in the structure of information space which is
20 basically organised as a tree with hyperlinks.

The patterns of activation of the pins can be used to give
a direction, e.g. a compass bearing or the direction of an object
from the cursor position. The patterns can also be used to
25 indicate what is under the cursor, or in the immediate vicinity.
By selecting objects, feeling the patterns and moving the
pointer, the user is able to explore a map, or other graphical
image, represented on the virtual surface.

30 One form of the input/output unit has six pins with the
associated transducers arranged as a hexagon about a seventh
central pin. The pins are used to guide the hand of the user
holding the tactile input/output unit in the direction
corresponding to the direction of the graphical object from the
35 cursor on the virtual surface. This allows the user to explore
the surface for objects which the user has selected. There is
means of selecting a single object or a group of objects with
shared characteristics.

With this particular input/output unit, the method of
5 finding a particular object and its shape is as follows.
Consider first a point object such as bus stop. While the window
is not over the object, the pin or pair of pins closest to the
object are activated periodically, with a period proportional to
distance. The user can then move the window towards the object,
10 and the frequency of activation increases as the object is
approached. When the window is directly over the point, the
central pin is activated. Next consider a line object such as
the centre line of a pavement along a street. While the window
is not over the object, again the pin or pair of pins closest to
15 the object are activated periodically. When the line is reached
the pins over the line are activated. The user can then follow
the line. While exactly over the line, the central pin is
operated. Now consider objects which have an area (i.e. are not
points lines). The same procedure is followed to find the edge
20 of the object. However if the window is moved inside the area,
the central pin is continuously activated, and the pins nearest
to the nearest edge are periodically activated.

A particularly useful aspect of the invention is the ability
25 of the user to feel the input as it is being drawn. Thus a person
can input a line onto a map by moving the pointing device and
then immediately feel the line using the tactile means.

For examining the relationship and shapes of different areas
30 of the map, different areas are allocated different "colours" on
the virtual surface, and each pin reacts to a different colour,
as the cursor is moved over the surface. The user can thus scan
the surface and detect the position of the different coloured
areas. This is particularly efficient as no map requires more
35 than four colours to distinguish different areas.

Sounds may be produced corresponding to, pin activation

above. Embodiments of the invention may have an audio output
5 where the sounds corresponding to pin activation are combined
with speech output of text information.

While the main outputs are tactile or audio a visual output
may also be provided as, for example, a word-by-word visual
10 display of text with large characters, where the display or
highlighting of each word is synchronised or partially
synchronised with the speech output of the word such that the
word is spoken immediately before, immediately after, or
simultaneously with the display of that word. The word-by word
15 facility is useful for partially sighted people as the visual
display can handle words in large characters, up to the width of
the screen. The word display or highlighting can be centred, such
that the person can retain focus on one point on the screen while
the words are displayed sequentially. This permits rapid reading,
20 since the eyes' saccade movements are eliminated, and the time
spent in backtracking and re-reading is avoided. The synchronism
with speech reinforces the association between the written and
spoken word, helpful for language learners and dyslexics.

25 It should be understood that the output unit of the present
invention may rest on a surface, or may be clipped to a part of
a wearer's apparel, such as a belt, or may be strapped to and
operated by one hand.

30 Moreover the central processing unit may be remote from the
input/output and may even be accessed by telephone and modem.

In a further modification of the input/output units previously
described, the units are provided with a transmitter, for example
35 an infra-red or a radio transmitter, or a transmitter and
receiver, providing a remote control link with an appliance or
system such as a television, a kiosk or an automatic telling

-11-

5 machine, thus enabling the user to control the appliance or system using a dedicated pattern of pin or key operation and have from an audio or tactile output from the central processing unit confirmation of the control command.

CLAIMS

5

1. Sensory communication apparatus comprising a central processing unit having a data store, an output processor, means for controlling the output of data from the data store to the output processor, and output means connected to receive data from
10 the processor, the output means being responsive to the output data whereby the output of the computer can be determined by one or more of the user's senses of touch, sound or sight.

2. Apparatus as claimed in claim 1, in which the means for
15 controlling the output of the data store comprises a pointing device.

3. Apparatus as claimed in claim 1 or claim 2, in which the output means includes tactile elements in the form of pins, each
20 having associated with it an electro-mechanical transducer.

4. Apparatus as claimed in claim 3, in which the pins are also associated with respective switches which are connected through an input processor to the central processing unit.

25

5. Apparatus as claimed in claim 3 or claim 4, in which the pins are arranged in pairs each for simultaneous contact by a respective finger and each pin of each pair can be vibrated at different frequencies or with different pulse lengths.

30

6. Apparatus as claimed in any of claims 3 to 5, in which the output means is operable in either a character mode or a surface mode.

35 7. Apparatus as claimed in any of claims 3 to 6, in which the patterns in which the pins are actuated are related to text characters.

8. Apparatus as claimed in any preceding claim, including a
5 speech synthesiser responsive to data output from the central
processing unit.
9. Apparatus as claimed in any of claims 1 to 3, or any of
claims 5 to 8 when independent of claim 4, in which a keyboard
10 or keypad is connected through an input processor to the central
processing unit.
10. Apparatus as claimed in claim 9, in which the keyboard or
keypad is operable in a character mode or a control mode.

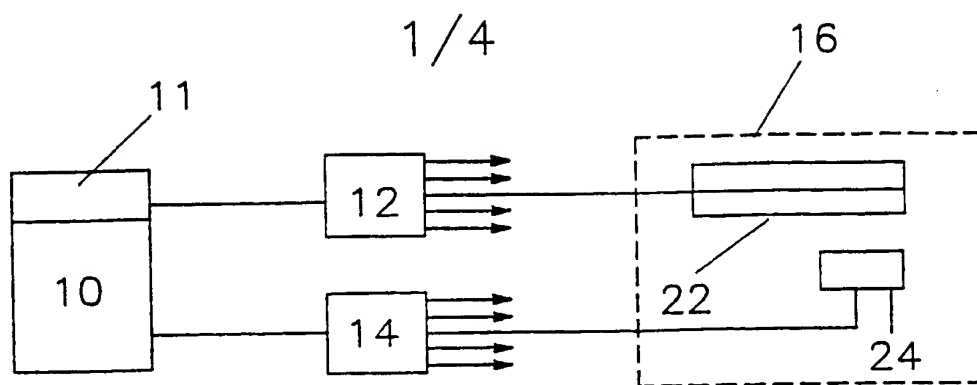


Fig. 1

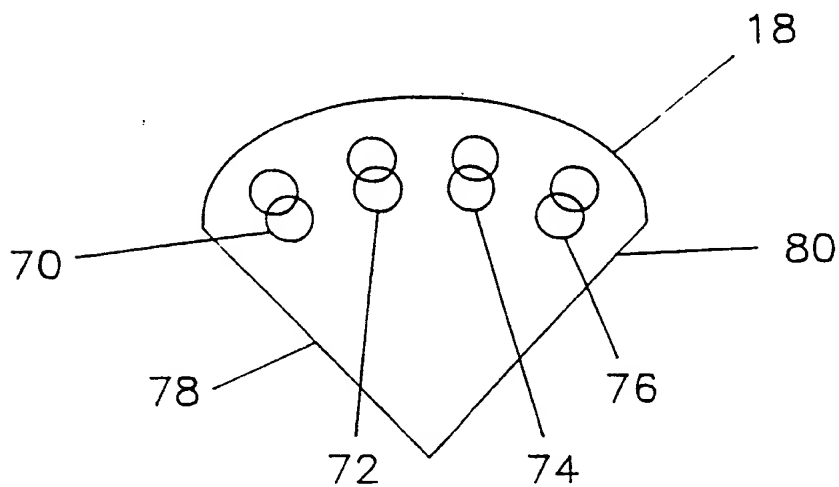


Fig. 5

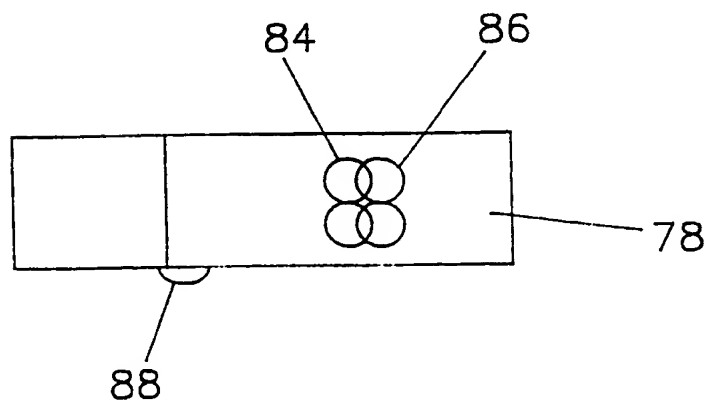


Fig. 6

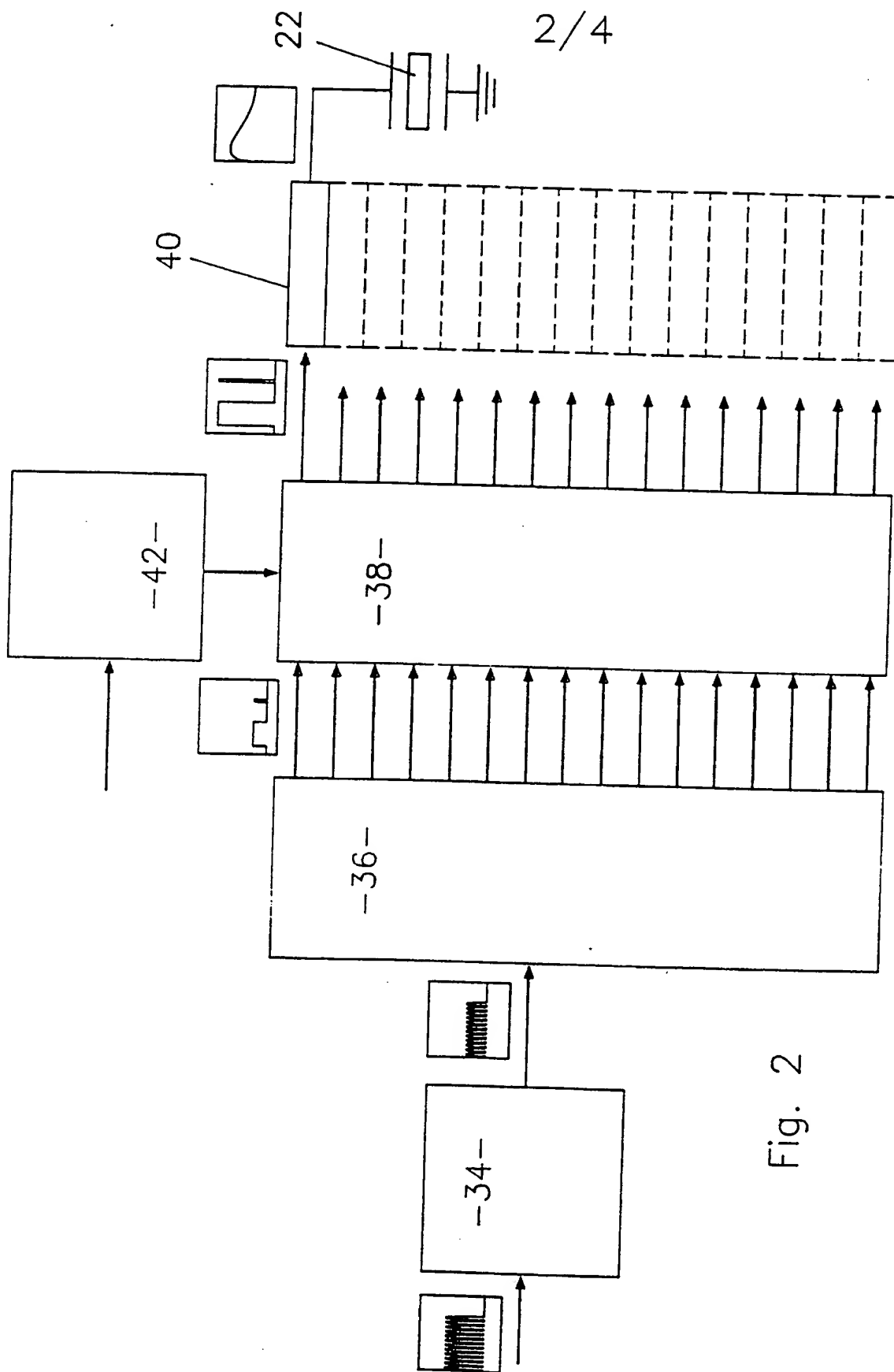


Fig. 2

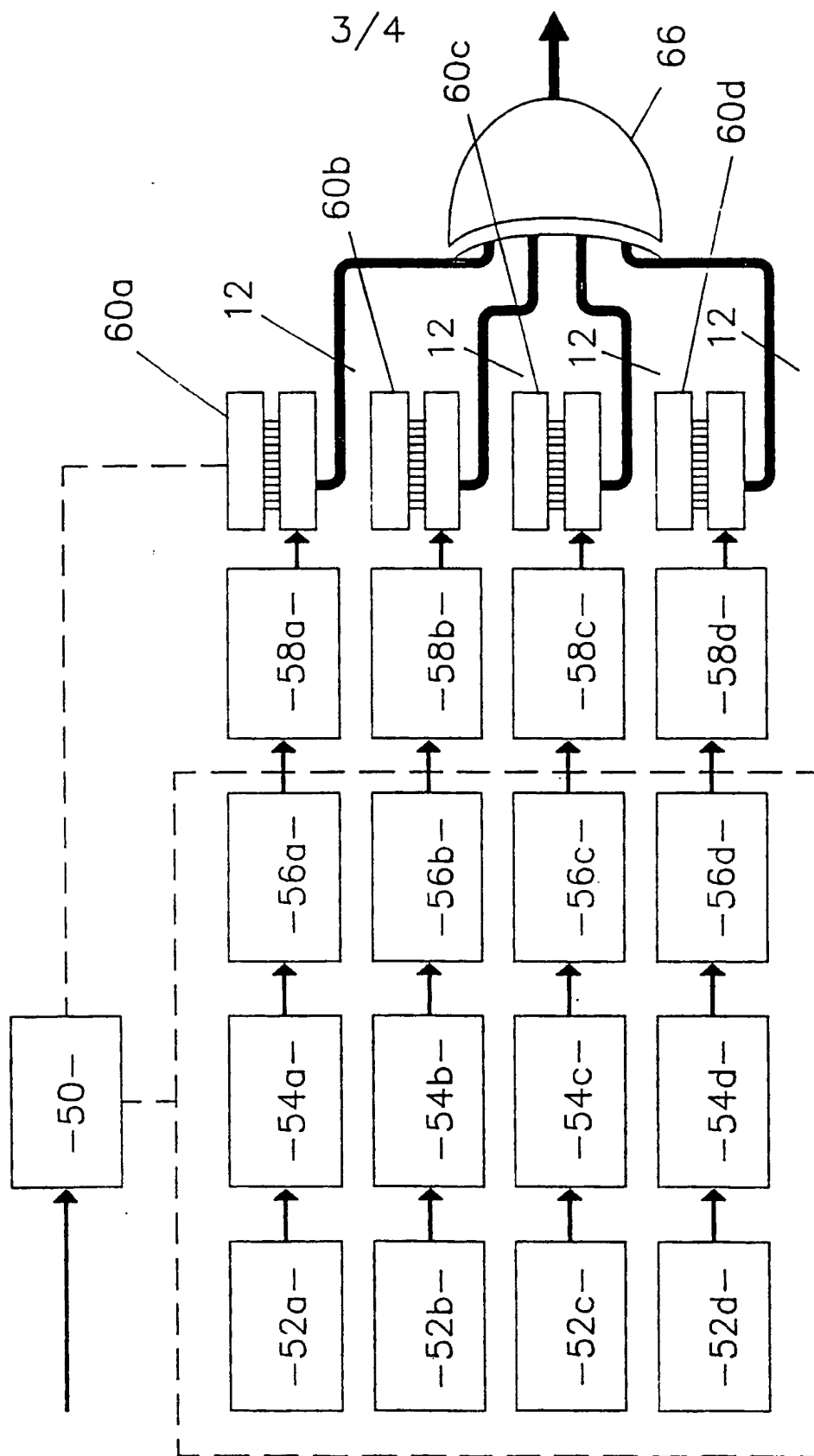


Fig. 3

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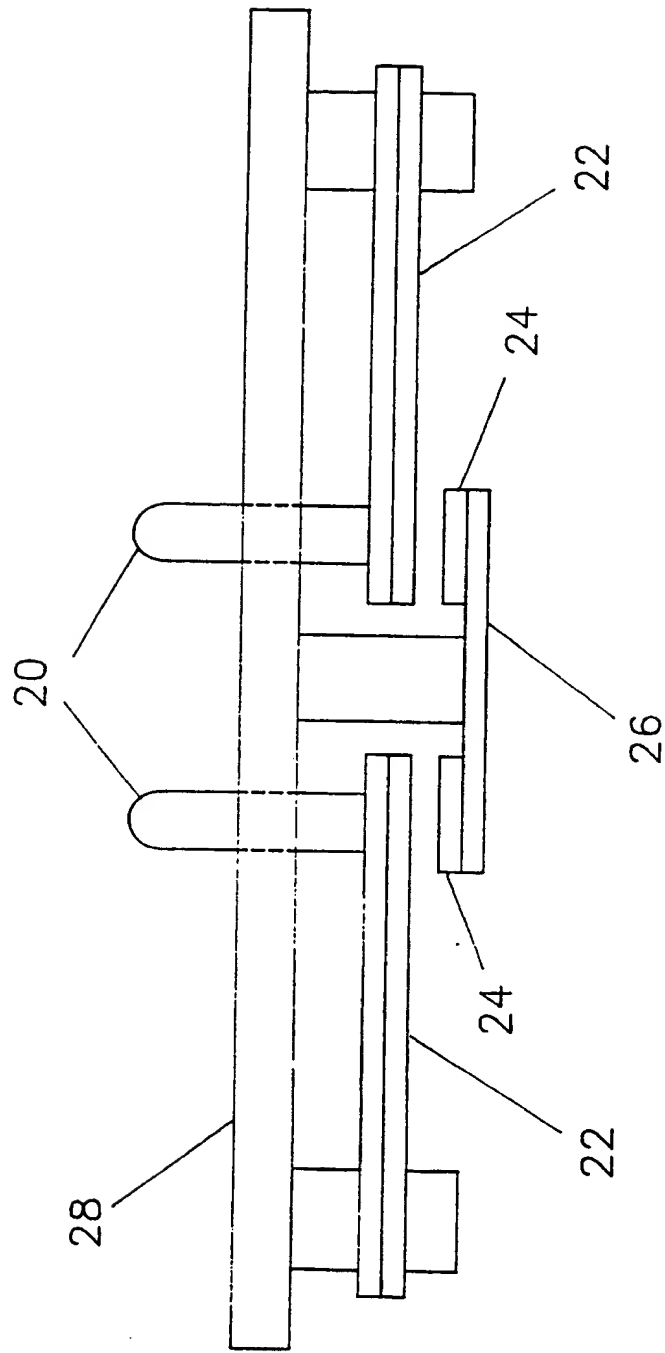


Fig. 4

INTERNATIONAL SEARCH REPORT

In International Application No
PCT/GB 98/00162

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G09B21/00 G06F3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G09B G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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P, X	GB 2 311 888 A (NISSEN JOHN CHRISTIAN DOUGHTY) 8 October 1997 see the whole document ---	1, 3, 6, 7
Y	MINAGAWA H ET AL: "TACTILE-AUDIO DIAGRAM FOR BLIND PERSONS" IEEE TRANSACTIONS ON REHABILITATION ENGINEERING, vol. 4, no. 4, December 1996, pages 431-436, XP000636716 see page 431, column 1, paragraph 3 - page 436, column 2, paragraph 2 ---	1, 3, 6
A	--- -/-	4, 9, 10

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Int. Patent Application No.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International Application No

PCT/GB 98/00162

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